# METHODOLOGY FOR THE ESTIMATION OF RELATIVE BED STABILITY (RBS) USED IN PEAK FLOW AND CHANNEL MORPHOLOGY ANALYSIS

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If project analysis indicates that peak flows would cumulatively exceed the 10% detection limit identified in Grant et al. (2008), the calculation of RBS is one measure that could be used to evaluate the level of risk to bank stability and channel morphology (Olsen, Whitaker, & Potts, 1997). RBS is the ratio of critical flow parameters for bed load entrainment to the existing flow parameters during peak discharge and is useful as an index of stream channel stability. Low RBS values indicate that a channel has been undergoing some level of aggradation or degradation and is very sensitive to hydrologic changes. High RBS values indicate that a channel is very stable, and peak flows would have to increase significantly to cause channel instability. Olsen et al. (1997) detail the calculation of RBS using two different methods.

## Meanings of RBS Values

### RBS ≤ 1.0

- Significant movement of bed material occurs with flows up to bankfull, and changes in channel substrate particle size distribution, width, depth, slope, and or pattern occur.

### 1.0 < RBS < 1.6

- Channel stability is vulnerable to peak flow increases.

### 1.6 < RBS < 2.0

- Channel will likely remain stable unless significant watershed degradation occurs without adequate hydrologic recovery.

### RBS > 2.0

- Channel is considered very stable and would require peak flow increases of more than 100% to cause channel instability.

## Estimating RBS Using Streambed Shear Stress

Details on the calculation of RBS using streambed shear stress can be found in Olsen et al. (1997). This calculation requires a number of input variables. The following section details how these variables were estimated for the analysis.

### Density of Sediment

- Assumed to be 2,650 $kg/m^3$.

### Density of Water

- Assumed to be 997 $kg/m^3$.

## $D_{50}$

- This is the mean particle diameter and is calculated from field data.

## $D_{84}$

- This is the diameter of the $84^{th}$ percentile streambed particle and is calculated from field data.

## Hydraulic Radius

- Bankfull depth is used as an approximation of the hydraulic radius (Leopold & Maddock, 1953). This is measured in the field or obtained from prior monitoring data.
- Leopold & Maddock state that depth can be used to approximate the hydraulic radius of wider channels. For narrower channels, this method tends to underestimate the hydraulic radius. For the purpose of this analysis, this is acceptable because it will provide a more conservative estimate of RBS.

## Shield's Coefficient

- Petit found a value of 0.45 to be a good estimation and well aligned with other studies (Petit, 1994).

## Slope of Power Relationship

- Petit found a value of 0.7 to be a good estimation and well aligned with other studies (Petit, 1994).

## Water Surface Slope

- The channel slope of the reach is used as a surrogate. This value will either be estimated using a digital elevation model in GIS or measured in the field (preferred).

# Estimating RBS Using Streambed Shear Stress

Details on the calculation of RBS using stream discharge can be found in Olsen et al. (1997). This calculation requires a number of input variables. D50, D84, and water surface slope were estimated in the way described previously for the Streambed Shear Stress Method. The following section details how other variables were estimated.

## B (dimensionless exponent)

- This exponent was estimated using Equation 6 developed by Bathurst (1987). Although Bathurst's research is oriented toward steep, boulder-dominated streams – not gravel-bed streams, I am unaware of other methods for calculating this exponent.

## Bankfull Discharge

- This is estimated by using the USGS StreamStats online interface[1] to model the 1.5, 2.0, and 2.33 year peak floods.

[1] Accessible at https://streamstats.usgs.gov/ss/.

### Bankfull Width

- This is measured in the field or obtained from prior monitoring data.

### $D_{16}$

- This is the diameter of the $16^{th}$ percentile streambed particle and is calculated from field data.

## Literature Cited


Bathurst, J. C. (1987). *Critical conditions for bed material movement in steep, boulder-bed streams.* Paper presented at the Erosion and Sedimentation in the Pacific Rim, Corvallis, OR.

Grant, G. E., Lewis, S. L., Swanson, F. J., Cissel, J. H., & McDonnell, J. J. (2008). *Effects of forest practices on peak flows and consequent channel response: A state-of-science report for western Oregon and Washington* (General Technical Report PNW-GTR-760). Retrieved from Portland, OR: https://www.fs.fed.us/pnw/pubs/pnw_gtr760.pdf

Leopold, L. B., & Maddock, J., T. (1953). *The hydraulic geometry of stream channels and some physiographic implications*. Washington, D.C.: U.S. Department of the Interior, U.S. Geological Survey

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